Review of Application of a 1-D Heat Budget Model to the Columbia River System

Dated May 2001

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1. I would like to make the report's author(s) aware of the following two references, which I do not see listed in the report's "References Cited." I believe these references contain background information that might be of some interest for the report's readers:

(a). United States Department of the Interior, Fish and Wildlife Service, "Air and Water Temperature Studies for 1957, Middle Snake River Drainage, Idaho-Oregon-Nevada-Washington, A Progress Report." Portland, Oregon; April 1958.

(b). United States Commission of Fish and Fisheries, Part IV, Report of the Commissioner for 1875-1876, "The Salmon Fisheries of the Columbia River," by Livingston Stone. Washington, D.C., Government Printing Office, 1878.

Reference (a) is a very comprehensive compilation of various air and water temperature data taken within the Snake River Basin during the 1950's.

On page 807 of Reference (b) is a "table of daily temperatures of the water of the Columbia River at Clifton, Oregon" for the summer of 1875 which is somewhat interesting in that water temperatures above 68 degrees F (20 degrees C) were noted starting on July 17th of that year.

2. Figure 1-1 on page 1, a map of the study areas, does not show the location of the Anatone gaging station on the Snake River. Being this location at River Mile 168.9 is specifically referenced as being a study area boundary, recommend that this geographic point be shown on map Figure 1-1 for clarity.

3. Believe "minor portions of Nevada" are also drained by the Columbia/Snake River system, and should be listed under Section 1.2, page 2.

4. On page 3, Section 1.2, it is stated that "the headwaters of the Snake River are in Jackson Lake....". Since the Snake River has a Drainage Area (DA) of 800 square miles at Jackson Lake I recommend that this sentence be re-worded something like "The Snake River's headwaters are UPSTREAM of Jackson Lake" or similar. Also the major headwaters area is located north-east of Jackson Lake.

5. In Section 1.2, there is a phrase "stream flows increase until the snowpack can no longer support high flows." I recommend that this be changed to something like "stream flows increase until the snowpack is depleted" or something similar.

6. In Section 1.3, I believe the sentence which begins "The only segment of the Columbia River above Bonneville Dam which remains unimpounded...." should also contain the qualifying phrase "in the United States" because I believe unimpounded reaches do exist in Canada.

7. In Section 1.5 there is a discussion about the Clearwater River and a 1969 study by Moore; where one conclusion was "at no time did they produce a warming effect." It is interesting to note in the 1957 Air and Water Temperature Study by the US Fish and Wildlife Service (my Reference #1(a) above), late July temperatures found on the Clearwater River at Kamiah and on the North Fork Clearwater River at Ahsahka were sometimes WARMER than that noted on the Snake River at Clarkston UPSTREAM of the Clearwater River. This to me suggests that the Clearwater River might be capable of warming the Snake River.

8. An acronym listing would be helpful as there are quite a few contained in this report. Their true meanings are not always readily apparent to all readers.

9. Since the report compares "impounded and unimpounded conditions" within the Columbia River basin, it would be interesting to expand Table 1-2 found on the report's Page 4 to include "pre-and post-impoundment flow conditions" for the applicable gaging sites. For example, the Snake River's site at Ice Harbor, having a record of 1913-1992 could be subdivided into a "pre-project" time frame of 1913-1962 and a "post-project" period of 1963-1992. Similarly, the Columbia River at Grand Coulee, Columbia River below Priest Rapids Dam, and Columbia River at The Dalles each have substantial "pre-project" and "post-project" records available.

10. On page 10, a statement is made that "longitudinal dispersion is generally of great importance for one-dimensional models." However, under the discussion of "base equations" a qualification given on pages 11 and 12 for both the Eulerian and Lagrangian frames of reference is "assuming no longitudinal dispersion." Is this a significant issue?

11. On page 42 of the report it is stated that "the objectives of this study are to assess the relative contribution of impoundments and tributary inputs to changes in the thermal regime of the Columbia and Snake Rivers." It would be interesting to present (preferably graphically) the "inflowing Snake River temperatures" for the Snake River at Anatone gage, the Clearwater River at Orofino gage, and the Clearwater River at Spalding gage; which would give the reader an idea of the inflowing temperature regime to the Lower Snake River; and also present the temperatures at or near the mouth of the Snake River (vicinity of Ice Harbor Dam). This would provide some graphic comparison of the "inputs" and "outputs" with respect to water temperature of the Lower Snake River system.

12. What is the "definition of particle?" Is it defined on the "molecular scale" or on a "volumetric scale?" I personally struggle somewhat with seeing "particles" discussed when dealing with a "one dimensional model." Representing the real world with a 1-D model suggests some sort of averaging being done which to me removes "individual particles" from the discussion; and dealing with "averages of particles."

13. The elevations given for the Snake River in Table C-1 located in the report's Appendix C are all noted to be above the "normal operating pool elevations" for all four Lower Snake River projects. Is this significant or related to any conclusions made in the report?

14. Are the magnitudes given in Table 1-5 found on Page 7 degrees F or degrees C. I am assuming degrees C but this should be clearly specified.

15. Given that the four Lower Snake River reservoirs are on the order of 100 feet deep and the model is one-dimensional giving a daily cross-sectional averaged temperature, some discussion of the affects of this averaging (if any) would be interesting and helpful. Discussion of stratification would also be interesting.

16. On page 23, it states that "Lower Granite and John Day Reservoirs are the two largest run of the river reservoirs on the Snake and Columbia Rivers." However, Table 1-3 on page 5 gives a larger storage capacity for Little Goose than for Lower Granite. Is this table correct or is the statement on page 23 in error?

17. A footnote explaining the "Independent Scientific Group" is given on page 8 of the report. However, this group is referenced earlier in the report (such as on page 6 of the report); therefore it is recommended that this footnote be moved up to at least page 6, if not earlier in the report, for clarity.

18. As stated on page 6 of this report "water temperature is an important water quality component of habitat for salmon and other cold water organisms in the Columbia and Snake Rivers." As stated on page 12 of this report, "heat exchange across the air-water interface is generally the major source of thermal energy for lakes, rivers, and reservoirs." One question which I personally have not seen addressed in any of my readings is related to the "potential benefits of reservoir stratification on water temperatures." Addressing this question correctly is beyond the realm of the one dimensional models and would require a "multi-dimensional analysis" of the river/reservoir system, but to me would be an interesting one to investigate in the future. Under the "unimpounded natural conditions" the rivers likely were "well mixed" and thus had a more uniform temperature regime due to the more turbulent flows experienced under free

flowing conditions. However, with the reservoirs in place the system is likely more stratified with the upper layers likely being warmer than found in the natural well mixed system. However, to me the lower layers of the reservoir likely are "cooler than natural conditions" and since heat transfer is somewhat dependent upon a "temperature difference across the interface" (see Equation 8 on page 13 of report as an example of the temperature difference being used) to me having the reservoirs in place might result in less heat transfer from the atmosphere to the river system as compared to the "natural system," due to the decreased temperature difference across the interface (assuming the "upper layers of the reservoirs" are warmer than the "natural river temperature"). If water temperature is indeed a major issue, this perhaps might be a significant benefit of the reservoir system's construction. Being the salmon also live in the oceans it seems logical to me that "depth might not be an issue for them" and that having cooler water at depths of 30-100 feet might be acceptable habitat for their migration along the river systems.

19. With respect to equation (3) on page 12, what is the T_k term? Is it "true water temperature at time step k?"

20. On page 20 of the report, it is stated that "the hydraulic parameters must be determined a priori to the simulation. This is done through application of another model or methodology that provides the coefficients for input to the model. These then become model input conditions rather than parts of the overall simulation." I interpret this to mean that two separate modeling steps are completed here, the first being a hydraulic modeling effort followed by a heat budget modeling effort; using two separate models. Given the capability of the present computer resources it seems to me that it would be possible to combine the two modeling processes into one step, where both the hydraulics and heat budget could be calculated without resorting to the "a priori solution of the system hydraulics."

21. On page 25 of the report it is stated that "it is necessary to simulate daily average water temperatures as a FUNCTION of longitudional distance in the Columbia and Snake Rivers." To me this implies that there is some relation between river mile and water temperature; is this actually the case? If not, perhaps the sentence should be re-worded something like "simulate daily average water temperatures at various locations in the Columbia and Snake Rivers" or something similar.

22. On page 29 of the report an acronym SAMSON is used but not defined. Believe it is "Solar and Meteorological Surface Observation Network; which should be explained for reading clarity.

23. It is interesting to read on page 59, under the report's "Summary and Conclusions" that "the uncertainty in these estimates is approximately of the order of the estimated differences in the results." I assume the "differences" discussed here are between the "impounded or with reservoirs" and "unimpounded or without reservoirs" conditions.

24. My review copy was missing Figures D-1 through D-9; contained in Appendix D of the report. These figures present a regression analysis and are referenced on page D-1 of the report's Appendix D. Mention is made on page D-1 that "the linear relationship is constrained to pass through the origin of the coordinates (at X=0 and Y=0)" but I can't find the reason/rationale for imposing this constraint. Table D-10 of Appendix D also references this imposed constraint.